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ABSTRACT

This guide discusses the assessment of heart rate and, in particular, the assessment of heart rate using a heart monitor. Part 1, "Foundation for the Use of Heart Rate," reviews literature about heart rate assessment and heart rate monitors, offering an overview of national guidelines for physical activity. It focuses on the importance of physical activity, measures of physical activity, validity and reliability of heart rate monitoring, and validity of heart rate measurement instruments. Part 2, "Practical Applications of Heart Rate Monitoring," discusses ways to assess heart rate, then notes general uses of heart rate monitors and the use of heart rate monitors for educational purposes (assessing fitness, assessing effort, grading, assessing effectiveness of instruction, and rubrics). This part also features various applications used by K-12 teachers. A list of relevant resources is included. (Contains 51 references.) (SM)

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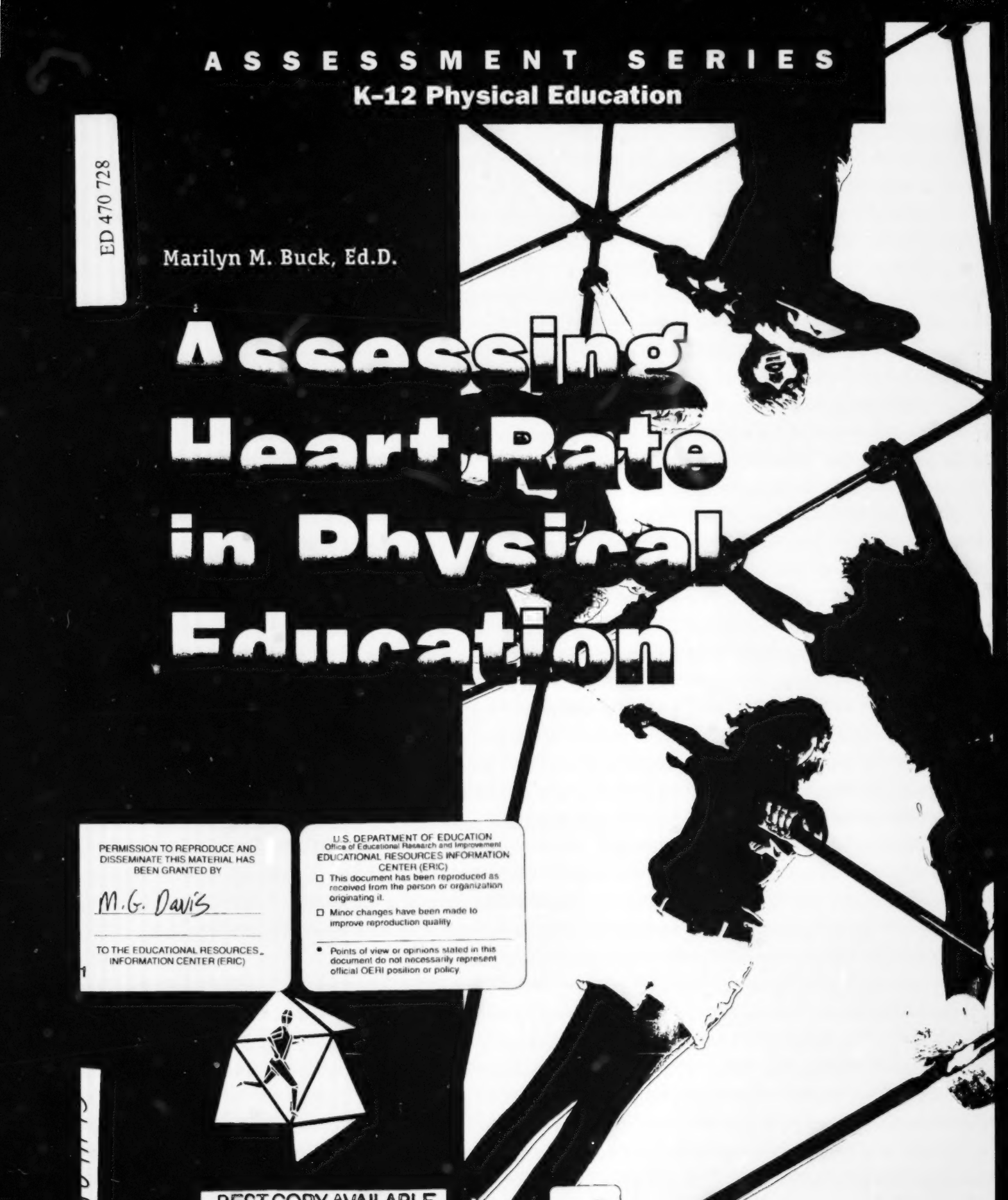
ASSESSMENT SERIES

K–12 Physical Education

ED 470 728

Marilyn M. Buck, Ed.D.

Assessing Heart Rate in Physical Education



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ASSESSMENT SERIES
K-12 Physical Education

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Assessing Heart Rate in Physical Education

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National Association for Sport and Physical Education
an association of the American Alliance for
Health, Physical Education, Recreation, and Dance

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PREFACE

Assessment improves student learning, not just monitors it. Assessment is on-going and continuous. Assessments are learning experiences. Assessment provides feedback to learners. Assessment engages students in applying what they learn. Assessment motivates students to achieve. Assessment, if done well, makes teaching "to the test" desirable. Assessment involves tasks that are valued. Assessment values the process of learning. Assessment leaves room for students to monitor and self assess their own learning.

Current reform efforts focused on assessment are about curriculum and instruction as well as assessment. Selecting outcomes that are meaningful and relevant to students is as critical as selecting instructional strategies that will challenge students to strive toward achieving them. Designing assessments that allow students to demonstrate that they have achieved these important outcomes must be relevant and reflect "real" life. These authentic assessments become the link between curriculum and instruction. This suggests that changing the "how" and "what" of assessment so that it is a part of the entire teaching-learning process and provides documentation of student learning is critical—critical to student learning and their desire to learn. We know that carefully considered and well-designed assessments can improve the quality of teaching and increase the amount of student learning. Assessments can track student performance progress and allow them to take responsibility for their own learning and improvement. Taking ownership will also result in greater motivation and achievement of students.

We have seen new forms of assessment that move responsibility into the hands of learners (self and peer assessment). We have also seen new tools developed to assess student performance in more authentic ways (journals, portfolios, community projects). These assessments are beginning to change the face of curriculum and instruction and the relationship between student outcomes, instructional delivery, and student achievement. Those of you designing and implementing these assessment processes are the source of these changes and the link to future reforms.

The intent of the NASPE Physical Education Assessment Series is to provide resources in the form of a collection of current, appropriate, and realistic assessment tools for physical education professionals. These resources are being developed for physical educators teaching children and youth in schools and for faculty preparing prospective physical education teachers. The series will be a forum for these professionals to share their ideas and successes with innovative assessment strategies.

We intend this series to be an on-going source of ideas, applications, and strategies for assessing student performance. The format will include individually published articles that may be purchased separately or as a continuing series package. Each paper will focus on a specific assessment topic (e.g., journaling, portfolios, game play recording tool), rationale for its use, how it might be used in practice, description of its link to one or more of NASPE's standards projects, and will include an example of the assessment tool. It is our desire that this series become an invaluable tool for teachers.

Deborah Tannehill, Ph.D.

INTRODUCTION

Cardiovascular health and cardiovascular fitness have become focal points in advocacy for active lifestyles and physical fitness generally. Since the late sixties when "aerobics" was introduced, there has been increasing refinement of techniques for designing exercise programs and measuring cardiovascular function. Physical educators have adopted research-based techniques for teaching about as well as developing and maintaining all fitness components. Heart rate is a key indicator for estimating cardiovascular fitness. The use of heart rate monitors has come into wider use as teachers seek new techniques to educate and motivate students regarding cardiovascular fitness. Heart rate monitors provide opportunities to demonstrate heart rate changes during various kinds of physical activity, verify palpitation, and monitor intensity of exercise. It is critical to recognize that heart rate monitors are not diagnostic instruments or appropriate for assessing fitness levels.

For years physical activity specialists, including physical education teachers, have taught their students how to measure their heart rates and to use this information to estimate the intensity of physical activities. Individuals have been taught the FITT principle for improving cardiovascular health. This principle states that individuals must participate in an activity at the appropriate (F)requency level, at the appropriate (I)ntensity level, and of the appropriate (T)ype for the appropriate (T)ime. The appropriate type of activity is one that requires the heart rate to remain in an appropriate range to produce training effort throughout the activity. Whereas the American College of Sports Medicine (ACSM) has relaxed its recommendations to encourage more physical activity for all populations, application of the FITT principle is still considered appropriate to achieve significant improvement in cardiovascular health in adults. The concept of target heart rate is well established for older adolescents and adults; however, it may not be appropriate for younger children and youth.

Individuals have relied on counting heart rate by palpating the carotid (neck) or radial (wrist) arteries. Using the palpating method to determine heart rate during activity has some limitations. First, some individuals have difficulty feeling their pulse. Second, palpation of the carotid artery stimulates the vagal nerve, which in turn can decrease heart rate, giving a false interpretation of actual exercise intensity. Third, counting is troublesome when breathing hard from an exercise bout or activity session. Finally, recommendations for using this method include ceasing activity to locate and count the pulse rate. Cessation of activity, while necessary, results in a slowing of the heart rate, which occurs more quickly in more fit individuals. These factors contribute to a measure that, at best, represents an estimate of heart rate at a particular moment in time, rather than the actual heart rate *during* activity. An electronic heart rate monitoring device allows a person to determine heart rate without stopping and manually counting and, therefore, has the potential to provide a more accurate assessment of heart rate. In recent years, heart rate monitors have been developed that are convenient and accurate for use during exercise.

When considering use of heart rate monitors, a potential concern is that physical education teachers are not trained to use heart rate information to prescribe exercise levels. The American Heart Association (AHA) has warned that heart rate monitors should not be used by untrained individuals to prescribe exercise or diagnose cardiac problems. Generally, the education to become a physical education teacher does not prepare a teacher to diagnose heart problems, nor should a teacher attempt to do so.

The purpose of this book is to discuss the assessment of heart rate and, in particular, the assessment of heart rate using a heart rate monitor. In order to emphasize the appropriate use of heart rate monitors by physical education teachers, the book is organized in the following manner. Part I provides a foundation for the use of heart rate to measure cardiovascular fitness and/or physical activity and discusses the validity and reliability of using heart rate monitors to assess heart rate. The majority of this section is a review of literature about heart rate assessment and heart rate monitors. An overview of national guidelines for physical activity is also provided.

Part II discusses ways to assess heart rate. This is followed by general uses of heart rate monitors and the use of heart rate monitors for educational purposes. Various applications used by K-12 teachers are presented in this section. Additional ideas are available in the following references: Hinson, 1994; Kirkpatrick and Birnbaum, 1997; Mohnsen, 1999; Oldaker and Schiltz, 1999; Strand and Mathesius, 1995; Strand, Mauch, and Terbizan, 1997; and Strand and Reeder, 1993. The contents of this book reflects appropriate practice in the use of heart rate monitors in physical education programs.

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PART 1

Foundation for the Use of Heart Rate

This section provides a foundation for the importance of physical activity, the use of heart rate as an indicator of cardiovascular fitness and as a measure of physical activity, and the validity and reliability of using heart rate monitors to measure levels of physical activity. Physical activity guidelines for children and adolescents as defined in several consensus documents are also identified.

Importance of Physical Activity

In 1992 the American Heart Association (AHA) identified physical inactivity as a major risk factor for coronary heart disease, along with cigarette smoking, high blood cholesterol, and high blood pressure (Deal & Deal, 1995). Shortly thereafter, the Surgeon General's Report on Physical Activity and Health was released (USDHHS, 1996). The 1996 landmark report reviewed all evidence regarding the benefits of physical activity to health status and raised an awareness of the risks associated with inadequate levels of physical activity (see Table 1 for a list of major conclusions from the Surgeon General's report). Furthermore, in 1997 the Centers for Disease Control and Prevention (CDC) published recommendations supporting regular physical activity for children and adolescents. The specific recommendations in the CDC report are based on evidence that regular participation in physical activity improves strength and endurance, helps build healthy bones and muscles, helps control weight, reduces anxiety and stress, increases self-esteem, and may improve blood pressure and cholesterol levels.

Although the relationship of physical activity patterns during childhood to physical activity patterns of adults is not fully understood, the evidence suggests that the physical activity patterns of adolescents are likely to continue into adulthood. Thus, an inactive teen has a greater tendency to become an inactive adult, thereby missing the benefits of regular physical activity as identified in the Surgeon General's Report (see Table 2). In fact, activity levels of individuals have been shown to decrease steadily with age. Because adolescence is a period of physiological change including peak development of bone mineral density (USDHHS, 1996), adolescents must be encouraged to engage in regular physical activity.

Through individual and collaborative efforts, a number of agencies have established recommendations regarding the amount and intensity of physical activity (ACSM, 1988; CDC, 1997; USDHHS, 1996). First, they agree, sedentary individuals will experience major health gains by adding daily physical activity. Second, all individuals should participate in regular (preferably daily) moderate activity. Third, for those who already participate in physical activity on a regular basis, additional health and fitness benefits will be realized by increasing the a) duration of moderate activity, b) intensity, and/or c) frequency. For adolescent (ages 13 – 18) populations, Sallis and Patrick (1994) provide the following guidelines for physical activity:

- All adolescents should be physically active daily, or nearly every day, as part of play, games, sports, work, transportation, recreation, physical education, or planned exercise, in the context of family, school, and community activities.

Table 1. Major Conclusions of the Surgeon General's Report Relating to Children and Youth

- People of all ages, both male and female, benefit from regular physical activity.
- Significant health benefits can be obtained by including a moderate amount of physical activity... on most, if not all, days of the week. Through a modest increase in daily activity, most Americans can improve their health and quality of life.
- Nearly half of American youths 12-21 years of age are not vigorously active on a regular basis. Moreover, physical activity declines dramatically during adolescence.
- Daily participation in physical education classes has declined among high school students from 42% in 1991 to 25% in 1995.
- About 14% of young people report no recent physical activity. Inactivity is more common among females (14%) than males (7%) and among black females (21%) than white females (12%).
- Participation in all types of physical activity declines strikingly as age or grade in school increases.
- Only 19% of all high school students are physically active for 20 minutes or more, five days a week, in physical education classes.
- Well-designed school-based interventions directed at increasing physical activity in physical education classes have been shown to be effective.

Source: U.S. Department of Health and Human Services, Centers for Disease Control and Prevention, and the President's Council on Physical Fitness and Sports *Physical Activity and Fitness Research Digest.*

- Adolescents should engage in three or more sessions per week of activities that last 20 minutes or more at a time and that require moderate to vigorous levels of exertion.
- Special groups require particular exercise prescriptions. For example, obese adolescents may benefit from a program of increased regular energy expenditure through physical activity. Blood pressure may be reduced in adolescents with hypertension by vigorous activity 3-4 times per week (Rowland, 1999, p. 2).

Table 2. Benefits of Regular Physical Activity

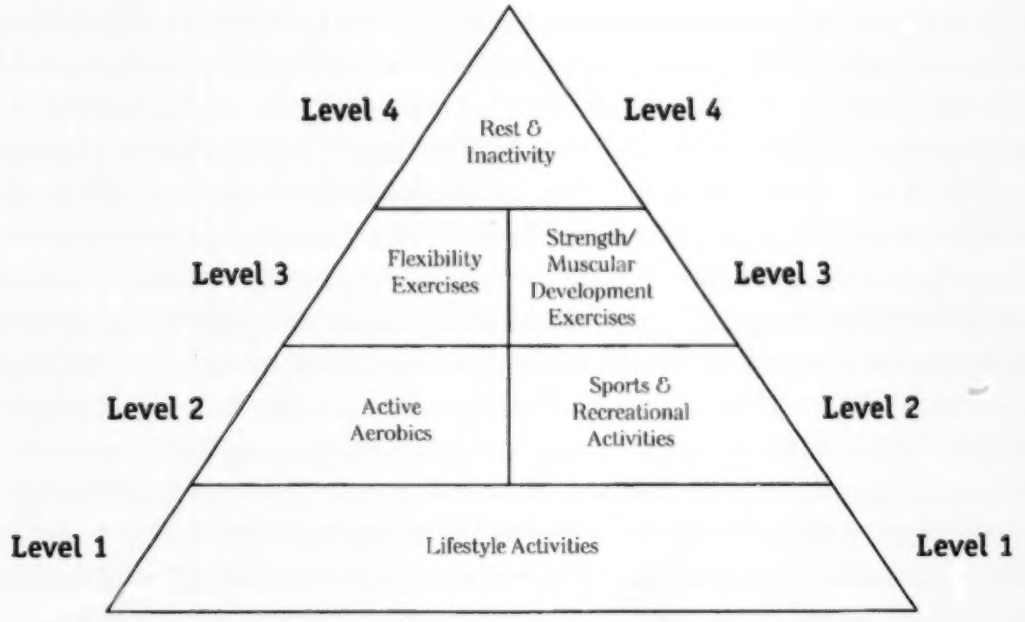
- Reduces the risk of dying prematurely.
- Reduces the risk of heart disease and stroke.
- Reduces the risk of developing diabetes.
- Reduces the risk of developing high blood pressure.
- Helps reduce blood pressure in people who already have high blood pressure.
- Reduces the risk of developing colon cancer.
- Reduces feelings of depression and anxiety.
- Helps control weight.
- Helps older adults become stronger and better able to move about without falling.
- Promotes psychological well-being.

Source: Surgeon General's Report on Physical Activity and Health, 1996.

The National Association for Sport and Physical Education (NASPE) provided guidelines for appropriate physical activity participation for children ages 5-12 in *Physical Activity for Children: A Statement of Guidelines* (Corbin & Pangrazi, 1998). The following were recommended:

- Elementary school children should accumulate *at least 30 to 60 minutes* of age- and developmentally appropriate physical activity from a variety of physical activities on all or most days of the week.
- An accumulation of *more than 60 minutes, and up to several hours per day*, of age- and developmentally appropriate activity is encouraged for elementary school children.
- Some of the child's activity each day should be in periods lasting 10 to 15 minutes or more and include moderate to vigorous activity. This activity will typically be intermittent in nature, involving alternating moderate to vigorous activity with *brief periods* of rest and recovery.
- *Extended periods of inactivity are inappropriate* for children.
- *A variety of physical activities selected from the Physical Activity Pyramid are recommended* for elementary school children (Corbin & Pangrazi, 1998, p. 3).

The Physical Activity Pyramid



Adapted from Corbin, C. B. and Lindsey, R. (1997). *Fitness for Life.* (4th ed.), Glenview IL: Scott, Foresman and Co.

Quality physical education programs were identified as part of the solution to physical inactivity among children and adolescents in all of the reports previously identified. The delivery of quality physical education programs is the responsibility of physical education teachers. Physical educators have the opportunity to influence the activity patterns in children and adolescents through developmentally appropriate instructional programs. Specifically, the physical education teacher is in a position to teach students about the benefits of physical activity and the risks associated with inactivity as well as to help students develop the abilities to engage safely in and enjoy physical activity for a lifetime.

The benefits of regular physical activity have been very clearly delineated (USDHHS, 1996). Recommendations for physical activity include the terms *moderate* to *vigorous* in reference to intensity. In an educational arena, efforts to improve physical activity patterns of youth should also include an understanding of *intensity*. Intensity in physical activity settings is inferred through measures of heart rate and energy expenditure.

Measures of Physical Activity

A review of the literature in this area revealed that self-reporting and activity counters have also been used to determine physical activity intensity with children and adolescents. The remainder of this section will address the various methods used to determine intensity of physical activity, especially as applied to children and adolescents.

Several methods of measuring physical activity have been used and tested with adults and children. These include self-reporting, either through the use of a diary or with an interview; activity counters, such as the Caltrac accelerometer and the Tritrac-R3D activity monitor; and monitoring heart rate by various means. Saris, Snel, and Binkhorst (1977) suggested that valuable information about daily physical activity can be gained by measuring heart rate and that a device that could be used to make field measurements accurately, rather than strictly laboratory measurements, was needed.

Self-reporting of physical activity is moderately accurate for adults, but children may not accurately report their activities (Sallis, Buono, Roby, Carlson, & Nelson, 1990). Parents cannot accurately report a child's activities throughout a day since they do not observe their child for a large portion of the day when the child is in school. Any device worn that connects to a larger device, such as an ECG, hinders the activity level of children. Children's behavior patterns have suggested that the use of heart rate telemetry (wireless heart rate monitors) is the most effective means of tracking physical activity of children, especially in field settings (Gilliam, Freedson, Geenen, & Shahraray, 1981; Saris, 1986). Heart rate monitoring has been identified as a valid means of estimating energy expenditure and intensity of physical activity. In fact, this method has been used to validate other methods and instruments. Heart rate monitoring was used to validate activity counters such as the Caltrac accelerometer (Sallis, Buono, Roby, Carlson, & Nelson, 1990), the Tritrac-R3D activity monitor (Welk & Corbin, 1995), the Computer Science Application (CSA) accelerometer (Janz, 1994), as well as interviewer- and self-administered physical activity checklists for fifth-grade students (Sallis, et al., 1996).

Estimates of energy expenditure are often used to determine appropriate physical activity levels. Heart rate monitoring has been determined to be a valid means of estimating energy expenditure (Saris, 1986). Kalkwarf, Haas, Belko, Roach, and Roe (1989) found that heart rate monitoring estimated energy expenditure of groups with a 4% error rate. Spady (1980) determined that heart rate monitoring was as accurate as direct measurement of oxygen consumption and a much more acceptable process for children. Using heart rate as compared to whole-body calorimetry had a mean linear correlation coefficient equal to .941 (Ceesay et al., 1989). Whole-body calorimetry requires the subject to enter a whole-body calorimeter and spend a period of time sleeping, exercising, etc. This equipment is not available or practical in field settings. Ceesay, et al. (1989) stated, "The satisfactory predictive power and low cost of the [heart rate monitoring] method makes it suitable for many field and epidemiological applications" (p. 175).

Saris (1986) and Freedson (1989) identified heart rate monitoring as a valid and objective measure of physical activity in children. Janz (1994) also agreed that "heart rate monitoring is appropriate for use in field settings" (p. 369). Armstrong (1998) reported that data gathered from heart rate monitors provided an estimate of the activity levels of young people. The data collected by Armstrong indicated that a significant number of young people rarely participated in even 10-minute periods of moderate to vigorous physical activity. Armstrong concluded that "sustained periods of moderate to vigorous physical activity are not typical of young people's physical activity patterns, and only a minority of youngsters satisfy" (p. S14) recommended levels of physical activity. Alexander, Butcher, and Scanlan (1988) indicated that heart rate monitoring "can be used to estimate exercise intensity of various sports activities" (p. 42). Furthermore, Pate, Baranowski, Dowda, and Trost (1996) reported that a strength of their study was the "use of heart rate monitoring as an objective measure of physical activity" (p. 94).

Validity and Reliability of Heart Rate Monitoring

The validity of heart rate monitoring has been determined in several studies. Durant, et al. (1992) concluded that heart rate monitoring was reliable for use on young children from different ethnic and gender groups. Heart rate monitoring has also been compared to the use of an ECG (Karvonen, Chwalbinska-Moneta, & Saynajakangas, 1984). The two methods were shown to be equally valuable for measuring heart rate during activity.

O'Hara, Baranowski, Simons-Morton, Wilson, and Parcel (1989) reported moderately high correlations between heart rate and observed activity. Durant, et al. (1993) determined that using a variety of heart rate measures increased reliability. The indices that were most reliable were the percent of time above 120 beats per minute (bpm), the percent of time the heart rate was above 25% of the resting heart rate, and the percent of time activity levels were above 50% of the resting heart rate value. These last two measures adjust for differences in fitness levels of children. Janz, Golden, Hansen, and Mahoney (1992) concluded that heart rate monitoring was an objective, nonobtrusive method of measuring physical activity in children and adolescents.

Validity of Heart Rate Measurement Instruments

As identified, heart rate monitoring is considered to be a valid, reliable, and objective means of measuring physical activity; however, the instrument used to make the measurement must also be evaluated. Léger and Thivierge (1988) stated that manual palpated pulse readings often are inaccurate. They determined that some heart rate monitors are valid, stable, and functional, particularly those measuring the electrical activity with conventional chest electrodes, using a chest strap for a transmitter and a watch that receives the radio signal. Types of heart rate monitors that use a photocell to measure opacity of blood flow such as a device put on the earlobe or finger are not adequate for reliable heart rate measures. Concurrent validity correlations (r) for heart rate monitors using a chest strap transmitter ranged from .93 to .98. Low-intensity physical activity resulted in r =.95 with a standard error of estimate (SEE) of 4.2 bpm. A simple explanation of a SEE equal to 4.2 bpm is that the monitor was within 4.2 bpm of the actual heart rate measurement. High-intensity physical activity was valid at r =.71 with a SEE of 5.5 bpm. Whereas no values were given for reliability and stability, each were reported to be good.

Additional validation studies using heart rate monitors with a chest strap transmitter and a watch are discussed below. One study by Treiber, et al. (1989) compared a Sport-tester (European version of the Polar Vantage XL) to recorded ECG heart rates in children in both laboratory and field settings. The study of 10-year-olds found a correlation coefficient of .97 to .99. For children 4-6 years old, r =.94 to .99. A group of 7- to 9-year olds was tested doing physical education class activities such as standing, walking, jogging, throwing a ball, batting a ball, and playing on a jungle gym (r=.98). The SEE ranged from 1.1 to 3.7 bpm in these studies. The researchers concluded that the Sport-tester recorded valid heart rates for a range of activities involving upper and lower body movements.

Bar-Or, Bar-Or, Waters, Hirji, and Russell (1996) determined the validity and social acceptability of using the Polar Vantage XL for measuring heart rates in preschoolers. The children were ages 3-5 years. Concurrent validity as compared to an ECG for lying down was r =.99, for cycling r =.93, and for recovery r =.92. The students overall were positive about wearing the heart rate monitors—only 3-5% of the children chose not to wear the heart rate monitors. Similar validity measures were obtained by Zinkgraf, Squires, and Maneval (1983). Janz, Golden, Hansen and Mahoney (1992) also concluded that heart rate monitoring is an objective, practical method for measuring physical activity in children.

Godsen, Carroll, and Stone (1991) determined heart rate monitors to be an excellent method for estimation of heart rate. In their study the heart rate monitor was within 6 bpm of the ECG about 95% of the time. They did indicate, though, that heart rate monitors were susceptible to rapid changes in heart rate. "Most of the errors observed could be attributed to arrhythmias, anticipatory heart rate rises, and rapid adaptation to or recovery from exercise" (p. 514).

Noakes, Lambert, and Gleeson (1998) suggested that, even though heart rate monitors accurately record heart rates, there is no agreement about the limitations or the ways this information should be used to optimize exercise prescriptions. They reported that there was not a linear relationship between work rate and heart rate during exercises of long duration or in hot, humid conditions. Gleeson and Lambert (1998) stated that heart rate monitors were a useful tool for athletes, coaches, and sport scientists yet cautioned, "Factors other than oxygen consumption can influence heart rate during exercise. These factors include temperature, emotional distress, posture, food intake, the muscle groups recruited in the activity, whether the exercise is continuous or intermittent, and whether the exercise is dynamic or static" (p. S2).

In summary, heart rate monitors can produce reliable and valid measurements in a variety of settings with various populations. However, caution should be exercised in interpreting heart rate information because heart rate is susceptible to a variety of factors, including the environment, type of exercise, and individual variables.

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PART 2

Practical Applications of Heart Rate Monitoring

How to Measure Heart Rate

Heart rate can be determined in a field setting in three basic ways. The most common two are to palpate either the carotid artery in the neck or the radial artery in the wrist. The third method is to use some type of heart rate monitoring device.

To measure heart rate at the carotid artery site, the students should be taught to place two fingers just below and to the right of the Adam's apple if on the right side and to the left if taking the measurement on the left side. The students should press very lightly so that they do not slow down the blood flow. To measure at the wrist the students should turn one hand palm up and use the first two fingers from the other hand. Place the fingers just below the base of the thumb and move them around as necessary to locate the pulse best. The thumb should never be used to count pulse rate. Students should take multiple counts of resting heart rate to establish consistency.

Students may either count for 10 seconds and multiply by 6, or count for 15 seconds and multiply by 4. Counting for only 6 seconds (begin with zero) and adding a zero may be used with older students or students with more experience taking pulse rate. The 6-second approach should be used for two reasons. First, adding a zero is much easier than trying to do the multiplication. Second, students who are more physically fit will have a rapid decrease in heart rate when they stop moving, and it is necessary to stop moving to accurately count heart rate using these methods.

To accurately measure heart rate while moving, some type of heart rate monitor must be used. There are many different types as well as different levels of information provided, depending on the model of monitor used. One of the types available is a bar called Insta Pulse—when a student grabs it with both hands, the heart rate appears on a small screen. Another type of monitor uses the pulse from the finger by placing the monitor over the finger. Monitors also are available that clip on the earlobe and measure the opacity of the blood flow through the earlobe with a photocell.

The type of monitor that provides the most useful and accurate information has a chest strap that transmits the heart rate to a receiver. Some have a wire and others are wireless. The wireless type is easier to use in a physical education class because the wire of the other type can get in the way during physical activity. Depending on the model, the monitor can provide information about the current heart rate; the average heart rate for an activity; the percent of time in, above, and below a specified target heart rate zone; the length of the exercise session; and the maximum and minimum heart rates and interval times. Software packages that allow the information to be downloaded directly to a computer provide the opportunity to conduct many additional analyses.

Physical educators should never offer medical diagnoses of any kind. Monitoring students' heart rate may provide evidence of a heart rate pattern that is different from the majority of the other students' patterns. Teachers should share this information with a school nurse or indicate to parents that they might want to seek additional information from a doctor as an appropriate precaution. There are a number of documented examples of situations in which serious health problems have been identified after referral by a physical education teacher due to indications in physical education class.

One example is included in *Physical Education for Lifelong Fitness: The Physical Best Teacher's Guide* (Physical Best, 1999). A teacher in Alaska provided assignments to home-schooled students for their physical education class. One assignment required the students to count their pulse at seven different times during an activity and then graph the results. The graph one student sent was not like any other this teacher had ever seen. He sent it back and suggested that either the child had not completed the assignment correctly or that she might have a health problem. The parents contacted a

Heart Rate Definitions

Resting Heart Rate (RHR or HR_{rest}) – HR taken at rest may require a "resting period" during which the individual sits for five minutes prior to the assessment. RHRs decrease with improvements in cardiorespiratory functioning.

Exercise Heart Rate – HR determination during an exercise or activity bout. Predicted exercise HRs decrease with improvement in cardiorespiratory functioning (i.e., predicted using the HRR method).

Recovery Heart Rate – HR determination following cessation of activity. Often used to determine the amount of time it takes the HR to recover from a specified exercise bout. A decrease in the recovery time period is an indicator of improved cardiorespiratory functioning.

Target Heart Rate Zone (THRZ) – HR specified for an exercise or activity bout. THRZ represents the range of the HR during activity from low to high. Recommended ranges for a THRZ are based on the relatively linear relationship of HR with volume of oxygen consumption (VO_2) in adult populations.

physician. The child eventually had surgery for a potentially life-threatening heart problem. The parents were very grateful to a diligent physical educator who did not diagnose an illness but alerted the parents and suggested follow-up to determine if there was a problem.

Instructions for Using Heart Rate Monitors

Instructions for the use of chest strap-style heart rate monitors vary depending on the monitor and the individual capabilities of the monitor. Some basic monitors provide heart rates and no other functions such as notification if the user is outside a targeted heart rate range. Others allow the setting of timers and more than one target range. This type of heart rate monitor allows for several analyses of data collected by the monitor. The information can be manually recalled or downloaded to a computer.

For each chest strap-style heart rate monitor, some instructions are similar. These instructions relate to how to put the monitors on and the logistics of using heart rate monitors for an entire class.

Teachers use several methods for putting heart rate monitors on children. In one elementary school, the students check a posted list of those who are to wear the monitors that day. Each student on the list picks up a chest strap and elastic strap. Because the chest strap transmits information better if the strap is directly on the skin under the shirt, the students go to the locker room to put on the strap. After the students return to the gymnasium and sit down, they place the watches on their wrists.

In another elementary school, the teacher puts the chest straps on each designated student over the student's shirt and then puts on the watch. The girls go behind a mat standing upright in the corner of the gym to pull their shirts out over the strap. The boys go to a different corner. In both cases the process takes only a couple of minutes to complete.

In middle school and high school settings, the students pick up their transmitters on the way to the locker room. The transmitters need moisture to begin sending data, so the teacher can use a spray bottle to moisten the electrodes prior to giving the transmitter to the student.

Providing a heart rate monitor for each student in a class is not necessary except in cases where the data obtained by the monitor is necessary to complete an assignment. Having enough heart rate monitors so 10% of the class could wear them would be adequate. Obviously having more heart rate monitors would provide more information each day, but it can also increase the time required to manage the use of the monitors.

For heart rate monitors that alert the wearer when the heart rate is out of the target zone, a target zone must be set. The Karvonen Formula is used by some (Siegel, 1988; Strand, Mauch, & Terbizan, 1997) to calculate the target heart rate zone. The reader should be aware that the Karvonen Formula was not originally established for use with children and that the accuracy of the formula for children and young adolescents has been questioned.

Calculating Target Heart Rate Zone

The following methods of calculating intensity or the THR zone are prescribed to correspond with oxygen consumption in **adult** populations:

Calculation of THRZ using Maximal Heart Rate (HR_{max})

220 – age (.65 and .90) where

220 – age = HR_{max} (this estimated HR_{max} has a standard deviation of ± 10 to 12 beats)

.65 to .90 represents the percentage range of a maximal heart rate (i.e., 65-90%, which corresponds with 50-85% VO_{2R} the percentage of oxygen uptake reserve)

Example for 20 year old: 220 – 20 = 200 x .65 = 130 lower HR limit
220 – 20 = 200 x .90 = 180 upper HR limit

Calculation of THRZ using Heart Rate Reserve (HHR) (i.e., Karvonen Formula)

HR_{max} – HR_{rest} (.50 and .80) + HR_{rest} where

HR_{max} = 220 – age

.50 to .85 represents the percentage range of maximal heart rate (i.e., which corresponds with 50-85% VO_{2R} the percentage of oxygen uptake reserve)

HR_{rest} = Resting HR

Example for 20 year old: 220 – 20 = 200 – 65 = 135 x .50 = 67.5 + 65 = 132.5 lower HR limit
220 – 20 = 200 – 65 = 135 x .85 = 114.75 + 65 = 179.75 upper HR limit

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Because resting heart rates and exercise heart rates in children are higher than in adult populations and the prescribed methods for calculating target heart rate zones were developed with adult populations, application of these formulas using 220 bpm as the maximal heart rate value may not be appropriate for youth. Evidence exists to lower the predicted maximal heart rate for youth to a range of 195-200 bpm. Rowland (1993), in the text *Pediatric Laboratory Exercise Testing: Clinical Guidelines,* provided a review of existing literature on aerobic exercise testing protocols for children and reported, "There is no clear answer to the question of defining the maximal test in children. Some subjects provide an exhaustive effort at a maximal heart rate of 185 bpm . . . whereas others are at no more than 75% of maximal effort" (p. 34). Additionally, he concluded, "For practical guidelines, however, a peak effort resulting in a heart rate over 200 during treadmill running or 195 with walking or cycling usually indicates a maximal test" (p. 34). Pangrazi, Corbin, and Welk (1996) used 140 beats per minute (bpm) as the point above which the student is considered to be engaged at moderate intensity. Once a zone is determined, the instructions provided for the particular monitor should be followed to set the zone on the monitor.

To start the basic heart rate monitors, simply hold the watch next to the transmitter strap for a few seconds and the monitor will begin registering the heart rate. For other models, follow the instructions provided. Many of the more advanced heart rate monitors can mark segments of time for analysis later, so when to start and stop the monitor during class is not important. The software programs also allow for selecting segments of the data for analysis.

Some heart rate monitor types allow heart rate data to be saved and then downloaded into a computer. The exact procedure depends on the heart rate monitor being used. Typically, the procedure involves placing the heart rate monitor on or near an interface device attached to the computer. Once the data has been transferred to the computer, it can be saved, manipulated, and analyzed to provide information about the heart rate during the recorded session.

Figures 1 and 5 are examples of heart rate curves created from data collected by heart rate monitors and downloaded to a software program. In Figure 1, the activity session lasted just under 30 minutes. In Figure 5, it lasted a little longer than 45 minutes. The dotted lines in each graph represent the preset target heart rate zones.

The vertical lines on the time axis of Figure 1 represent the pressing of the red button on the Polar Vantage XL Heart Rate Monitor. The purpose of pressing the button is to select intervals within the data. Figure 3 is the information available as a result. The left column (Interm. time) is the time during the data collection session when the red button was pressed. The center column (HR) is the heart rate at that moment. The right column (Lap time) is the time between each press of the red button.

In each case, the heart rate recording interval was set at 15 seconds. Reviewing Figures 1 and 5 does not provide this information. Figure 2 is the listing of all heart rates at the time the data was saved on the monitor. These numbers are recorded at 15-second intervals. The other choices were 5- and 60-second intervals. Very little need exists to use a 5-second interval. The 60-second interval is used for long activities. It is especially useful for any activity over 90 minutes.

Figure 6 is a graph created from the same data as Figure 5. The graph represents the percent of the session that the heart rate was above, below, and in the preset target heart rate zone.

Educational Uses of Heart Rate Monitors

Uses of heart rate monitors to help students learn is an important factor in addition to monitoring heart rate. The process of monitoring heart rate allows students to better understand how the body responds to physical activity. Increased understanding of the response to physical activity creates opportunities for interdisciplinary assignments and experiences that contribute to the overall literacy of the students. Students whose level of exertion must be controlled to exercise safely can use a heart rate monitor for this purpose. Student use of heart rate monitors and assignments using the data collected contribute to developing student literacy in technology. Not all of these examples are appropriate for all grade levels. Some may be best used at a specific grade or level, and others may be adapted for various grades/levels.

How bodies respond to physical activity. Mohnsen (1999) suggested that the use of heart rate monitors helps students to learn about how their bodies respond to physical activity and can be used to facilitate interdisciplinary activities. One purpose of wearing a heart rate monitor in class is to assist student awareness of heart rates in relation to exercise intensity so that the level of exertion is appropriate for improving cardiovascular fitness levels. Examples of activities, some with interdisciplinary opportunities, that can be conducted using heart rate monitors are presented in Table 3.

Interdisciplinary ideas. Additional examples of interdisciplinary work for physical education classes and/or content to be covered by other disciplines using heart rate monitors include the following:

- Math—Calculate the number of heartbeats during a prescribed time, given the average heart rate during that time; calculate the target heart rate zone; and, using a manual recall function, record the heart rate at designated intervals and graph the results.
- Speech—Each student in class wears a heart rate monitor, which can be downloaded. At the time a person is to give a speech about any topic, the student pushes a button to record a mark that will appear on the printout. After downloading the data, each student completes a worksheet (Kirkpatrick & Birnbaum, 1997).

- English—Students keep a journal of experiences related to the use of heart rate monitors and write about the response of the heart to exercise and, in particular, the response of her or his heart to exercise as experienced in physical education class and physical activity outside of class.
- English—On different days throughout the semester, students could be asked to download their heart rates for different days and to interpret the information. For example, during the warm-up activity, what was their average heart rate? What was their recovery heart rate during the cooldown period? Throughout the lesson (or day's activity), were they in their target heart rate zone? The students could react and reflect on the information gathered. They could write about the potential effects of continuing the pattern of exercise demonstrated in that class. Also, because this would be done throughout the semester, the students could reflect on the progress made, such as changes in average heart rate, rate of speed of recovery, etc., as well as to discuss what needs to be done to show continued improvement.

These were just a few examples. Many more are possible and are only limited by the creativity of individual teachers. Although some of these activities could be adapted and completed without wearing a heart rate monitor and by manually counting heart rate, the heart rate measures are more accurate with the heart rate monitors. In addition, the use of heart rate monitors may increase student interest in the activities.

Table 3. Activities to Teach Body Response to Physical Activity

Students can use heart rate monitors to:

- Compare heart rates during two activities (e.g., football and jump rope) and write an essay stating which activity is more aerobic and why.
- Analyze their recovery heart rates (how long it takes to return the heart rate to normal after a workout) in order to determine their fitness levels.
- Analyze their own heart rate printouts for the mile run. (Printout and analysis can then be placed in either a regular portfolio or an electronic portfolio.)
- Participate in an aerobic circuit while maintaining the same heart rate; then write an essay describing the difference between pieces of exercise equipment.
- Complete a fitness assessment circuit that includes the following stations: blood pressure, curl-ups, body composition measurement, timed work for distance, back saver sit and reach, jump rope (with heart [rate] monitor), heart [rate] monitor interface for downloading of data, and push-ups. Write an essay describing their current fitness levels based on results at each of these stations.

From "Using heart monitors for curriculum integration," by B. Mohnsen, 1999, *Teaching Elementary Physical Education, 10*(1), p. 35.

Pacing—working in the THR zone. Students, especially young children, often struggle to work at a steady pace. For example, they sprint and then walk and then sprint again rather than run at a steady jogging pace. By using a heart rate monitor, students can see their heart rates. The teacher can select a heart rate (for example, 140 bpm), and ask each student to try to maintain that heart rate intensity level. Different levels of intensity can also be selected so students experience exercising at a steady pace at varying levels of intensity.

In one study, heart rate monitors were used to train adolescents and young adults with mental retardation to self-pace while exercising. The students learned to modify their pedaling rates during a 10-minute self-paced exercise session in a public school setting. The students did not want to hear the beep that sounded if their heart rates were not in the established heart rate zone. These students were successful in pedaling at a steady pace with the use of heart rate monitors (Ellis, Cress, & Spellman, 1993).

Perceived exertion. Teaching students to evaluate the intensity of their activity performance by using the Borg Scale, also known as rate of perceived exertion (RPE), can provide another means of self-assessment of effort. The Borg scale is a valid method of individual determination of intensity during aerobic endurance activities with conditioned, experienced exercisers (Brehm, 1998), but heart rate monitors can also be used to help students understand actual heart rate and perceived effort. One method for doing this is to ask students to wear heart rate monitors and to decide what they perceive their effort to be according to the Borg Scale. The perceived effort can be compared to the heart rate indicated on the heart rate monitor. After the students seem to be proficient and consistent in this procedure, cover the heart rate monitor face during the activity. Then ask the students their perceived effort and compare this with the heart rate again (but this time there is no visual information upon which to base a decision). When students become consistent, they are able to estimate effort without the use of heart rate monitors.

Homework assignments. Heart rate monitors can also be used for homework assignments in physical education. One example of a take home assignment is to study the heart rate demands of a parent or guardian's career. Students can take home a heart rate monitor and place it on a parent or guardian to wear throughout a workday. The parent is asked to push a button to mark the beginning and end of activities and to record what these activities were. The students can then study the events of the day to determine what activities might be stressful and the effects of stress on heart rate. They can also determine what activities during the day increased heart rate as well as the overall level of heart rate for the day. This will allow the class to develop a

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profile of the heart rate for a-day in the life of various professions and compare what they have learned (Mauch, L., 2000).

Another possibility is to send heart rate monitors home with students overnight or for the weekend. The students can be asked to demonstrate and explain to family members about resting heart rate and target heart rate zone and how each relates to exercise. Then the parent/guardian can be asked to wear the heart rate monitor for a specified time. The next day, the students can download the file and write a short report on their parent/guardian.

Unsupervised physical activity. Another important use of heart rate monitors is for unsupervised physical activity during physical education classes. This may occur when a student has an injury that prevents her or him from participating in the scheduled activities but a doctor has cleared the student to walk or ride a stationary bicycle. If the student wears a heart rate monitor, the teacher can determine the amount and intensity of exercise the student performed.

Exercise during pregnancy. When a student becomes pregnant, this often means the end of physical education classes. Clearly, participating in some physical education activities would be prohibited, but it is a time when exercise is needed for the benefit of the mother-to-be and the unborn child. Any activity should be undertaken only with the consent of the doctor, of course, but, generally, doctors indicate that, as long as the mother does not exceed a heart rate of 140 bpm, no harm will come to the fetus. Heart rate above 140 bpm can cause the mother's core temperature to approach levels that might be dangerous to the fetus. Of course, the mother's doctor should be consulted to determine the appropriate level of activity. With the use of a heart rate monitor, she can participate in some class activities, including walking or jogging, for the benefit of both mother and child without constant monitoring by the teacher to maintain effort at appropriate levels.

Exercising with asthma. An asthma attack can be a scary experience for both the student and the teacher and is potentially life threatening. Heart rate monitors can be used to assist asthmatic students in maintaining exertion below a level that might trigger an attack. This level for each student is different and again would have to be determined with the advice of a physician. The physician may advise the student to keep the heart rate low, and increase the level of exertion gradually. If any sign of distress occurs, the level of exertion should be decreased. This heart rate level, where the student can participate without incident, becomes the upper level for the student, especially during times of the year when there is more potential for problems.

Contributing to student literacy. A concern of legislatures who provide the funding for schools is students' development of literacy skills. Heart rate monitors provide many opportunities for physical education to contribute to literacy development. Providing evidence as to how physical education can make these contributions can help support the need for physical education. Several possible activities that can be completed in physical education classes and in cooperation with other teachers are presented in the interdisciplinary section.

Increasing credibility. Heart rate monitors may also contribute to greater credibility of the physical education program. The following events illustrate how this can occur. A student teacher used his heart rate monitor each class period during his student teaching experiences. Each evening he downloaded the information and shared it with the students the next day. The cooperating teacher was so impressed with what the student teacher was doing that he asked him to take 5 of his 10 minutes during a parent open house to explain to parents what they were doing with the heart rate monitors in class. A parent who was an exercise physiologist by training commented at the end of one of his presentations that it was about time that physical education used technology like heart rate monitors in classes. Obviously, a quality physical education program that is delivered appropriately is paramount, and using heart rate monitors may facilitate understanding of how physical education has changed. This may be a sign to parents that physical education is different from what they experienced, and they may then have a desire to learn more about the physical education programs in their schools.

National technology standards. The International Society for Technology in Education has developed a set of standards for K-12 students. The standards have been divided into six broad categories. Teaching students to use heart rate monitors and download the data to the computer can help students gain the proficiency defined in these standards. Table 4 lists the six broad standards with the performance indicators that may be met with the use of heart rate monitors. In italics under each standard and performance indicator listed is one or more example of how heart rate monitors can contribute to addressing the national technology standards for K-12 students.

Assessment Using Heart Rate Monitors

Presented in this section is the use of heart rate monitors in the assessment of fitness, effort, written/reflection assignments, grading, and effective instruction. This section also includes examples of rubrics that teachers have used and how heart rate information might be incorporated in student portfolios, as well as discussion of appropriate practice in the use of heart rate monitors for determining grades.

Fitness Assessment. Heart rate monitors offer the opportunity for students to choose different types of fitness assessments. One student could ride a stationary bicycle for 20 minutes and record the average heart rate and the distance traveled. Another student could run a mile and record the average heart rate and the time

required to complete the distance. Improvement in subsequent assessments would be reflected in more distance on the bicycle for the same average heart rate or a lower average heart rate for the same distance. In the run, a faster time with the same average heart rate would indicate an improvement in cardiovascular fitness.

Beth Kirkpatrick (Kirkpatrick & Birnbaum, 1997) developed the following mile run protocol using heart rate monitors. Once all students are wearing a heart rate monitor that can be downloaded to a computer, the students lie down for 5 – 10 minutes to determine a resting heart rate prior to the run. The students then move to the track and line up, ready to begin the mile run. As each student approaches the starting line, the teacher pushes a button on his or her monitor to mark the beginning of the run. Each student moves forward individually so there is no way to know who has the fastest or the slowest time because everyone starts at different times. Each time the student passes the start/finish line the teacher presses the button again. A student whose heart rate is too high can be told to slow down, and those who need to increase their efforts can also be so advised. The student is also asked to call out how many laps he or she has completed at the end of each lap. At the end of four laps, the student walks until the heart rate stops decreasing or has dropped 40 bpm. A recovery time is the period of time required after the mile run is completed and the above is accomplished.

Figure 1 is an example of a curve for a student using the above protocol. When the run section of the curve is selected, the computer software will determine the average heart rate for the run interval. Figure 2 is a listing of the heart rate every 15 seconds the monitor was recording heart rate data. The resting heart rate is the lowest number achieved prior to the run. The recovery time is determined by looking at the listing of heart rates and determining the time when the heart rate has dropped 40 bpm after the run. This time is subtracted from the

Table 4. Technology Standards for Students

Technology Concept	Performance Indicator	Heart Rate Monitor Contribution
Basic operations and concepts	Students are proficient in the use of technology.	*Basic operation of a heart rate monitor and how to download heart rate data to a computer.*
Social, ethical, and human issues	Students practice responsible use of technology systems, information, and software. Students develop positive attitudes toward technology uses that support lifelong learning, collaboration, personal pursuits, and productivity.	*Learning how to properly interpret heart rate monitor data and share this information with others, including parents/guardians.* *Wearing heart rate monitor and tracking fitness gains through use of heart rate monitor.*
Technology productivity tools	Students use technology tools to enhance learning, increase productivity, and promote creativity.	*Students learn about their level of effort and, therefore, productivity during physical activity each time heart rate monitor is worn.*
Technology communications tools	Students use a variety of media and formats to communicate information and ideas effectively to multiple audiences.	*Students use a computer to record experiences and reactions to using heart rate monitors.*
Technology research tools	Students use technology to locate, evaluate, and collect information from a variety of sources. Students use technology tools to process data and report results.	*Learning body's reaction to the stress of giving a speech.* *Downloading data and printing graphs and other information, creating graphs from manual recall of heart rate data.*
Technology problem-solving and decision-making tools	Students use technology resources for solving problems and making informed decisions. Students employ technology in the development of strategies for solving problems in the real world.	*Learning how to pace the body during physical activity.* *Discussing with parents/guardians the results of the information collected during homework assignments using heart rate monitors.*

Source: International Society for Technology in Education, 1998, *National Educational Technology Standards for Students*, pp. 5-6. Copies can be ordered from ISTE, 480 Charnelton St., Eugene, OR 97401 or by accessing www.iste.org. Items in italics added by author.

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Figure 1. Heart rate curve created from a heart rate monitor– 30 minute session.

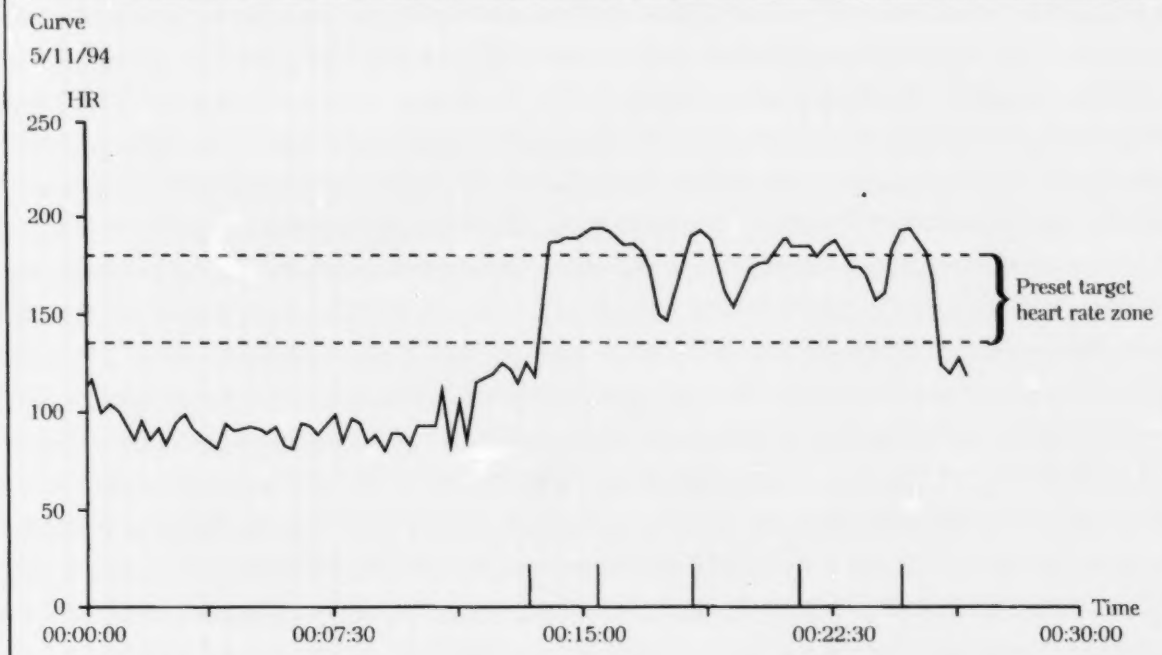

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Figure 2. Heart rate values from a heart rate monitor.

Listing
5/11/94
Stopwatch: 00:26:34.1 HR 119

Time	Heart Rate Values (15 second intervals)											
00:00	111	117	99	104	101	93	85	95	85	92	83	94
00:03	99	92	87	84	81	94	90	91	92	91	89	92
00:06	82	81	94	93	88	94	99	84	97	94	84	88
00:09	79	89	89	82	93	92	92	111	81	106	84	115
00:12	117	119	125	122	114	125	118	148	187	187	189	189
00:15	191	194	194	192	188	185	186	183	171	150	147	162
00:18	180	190	193	188	176	161	153	161	173	176	176	182
00:21	189	184	185	185	179	185	188	182	174	174	169	157
00:24	160	182	193	194	190	182	165	124	120	128	118	

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time the mile run was completed. Figure 3 lists the interval times for each lap. The mile run time is determined by adding the four lap times or subtracting the time of the last intermediate time from the first intermediate time. For the example in Figures 1 through 3, the resting heart rate is 79 bpm (from Figure 2); the mile run time is 11:11.1 (from Figure 3); the average heart rate during the run is 179 bpm; and the recovery time is 1 minute, 15 seconds. The average heart rate is determined by using the computer software and selecting the mile run portion of the curve. The average heart rate is a menu selection. The recovery time is found by using the last intermediate time (24:36.5 on Figure 3), which would be the 194 bpm heart rate in column four on the last line of Figure 2. Then count the number of 15-second intervals that follow to a drop of 40 bpm (154 or below). In this case there are five for 1 minute, 15 seconds.

Students should be taught to self-assess their fitness levels as well. The above protocol could be used for self-assessment. Appropriately aged students can be taught to complete the same assessments and to record progress throughout the year. Improvements in any of the above measures indicate improvement in cardiovascular fitness.

Heart rate monitors can be used with any cardiovascular fitness assessments. In any situation in which students are pre-tested and then post-tested to determine fitness gains, there is a tendency by some to "sandbag" the pre-test or, in other words, to give less than a best effort. With the use of heart rate monitors, the level of effort during the fitness pre- and post-test can be measured, recorded, compared, and evaluated to report an accurate picture of effort and change in fitness from pre- to post-test.

Assessing Effort. Some teachers include effort as one of the factors used in determining grades. Generally this is a subjective measure and a difficult one to make.

Figure 3. Data collected from a heart rate monitor.

Intermediate Times
5/11/94

Start time: 01:35:07 PM Stopwatch: 00:00:00.0
Final time: 02:01:41 PM Stopwatch: 00:26:34.1

Interm. Time	HR	Lap time
00:13:25.4	126	
00:15:27.3	196	00:02:01.9
00:18:20.8	192	00:02:53.5
00:21:31.1	185	00:03:10.3
00:24:36.5	194	00:03:05.4
	179 Avg. HR	11:11.1 Total lap time

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Everyone has watched an outstanding runner move in a seemingly effortless fashion around a track while others seem to struggle. Is one individual putting forth more effort than the other? Observations of their performances would suggest this is true, but is this an accurate measure? What about the obese student who is walking when all others are running and, even more importantly, what about the student who is not overweight but whose heart rate is at 180 bpm although he or she is walking or running very slowly? The latter student is one who is often told to work a little harder or to run faster, which is not necessarily appropriate encouragement.

Heart rate monitors provide a means of measuring effort. This means an obese student may be walking slowly while a fit athlete is running fast and both may be putting forth similar effort as measured by heart rate. Earlier sections of this monograph provided research to support individualizing instruction as an appropriate practice. When heart rate monitors are used and students are told that it is not how fast or how far they run/walk but that their heart rates must be within a certain range for a particular interval, students do not question those who are walking. It means each student has an equal opportunity to demonstrate effort, which is important to developing self-esteem, a positive self-image, and self-efficacy for participating in particular activities.

Effort can also be determined for game play as well as more traditional fitness activities. Mitchell and Oslin (1999) wrote a monograph on assessing game performances. The instrument they created was called the Game Performance Assessment Instrument (GPAI). Mauch (2000) adapted their GPAI to include effort. A sample GPAI data collection sheet is found in Figure 4. Mauch indicates that, from her experience, students who are held accountable for their efforts try harder. One way to make a fair assessment of effort in game play is to use heart rate monitors.

Grading. Assessments should be based on clearly defined educational goals and student achievement should be based on individual progress relative to goals and objectives, according to the National Association for Sport and Physical Education (*Appropriate Practices for Middle School Physical Education*, NASPE, 2001). One purpose of grades is to inform "students, parents, and administrators of the present status and progress of students toward program objectives" (Harrison, Blakemore, & Buck, 2001, p. 304). A grade should reflect the level of individual student achievement as compared to the course objectives. However, due to the fact that heart rate is influenced by a number of factors, it is not appropriate to grade students on heart rate information such as time in target range, recovery time, etc.

The following recommendations relate to using heart rate monitors for grading purposes. First, heart rate data should not be the means of grading but only one of several indicators of cardiovascular fitness. It is recommended that grades be based on continuous, formative evaluations as well as more comprehensive tests at the end of units of instruction (NASPE, 2001).

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Figure 4. Sample GPAI Data Collection Sheet for Soccer

Class: Period 4 A **Teacher:** Mrs. Mauch **Team:** Yellow **Game:** Soccer

Observation Dates: a) 3/12/00 b) 4/13/00

Scoring Key:

5 Highly Effective Performance
4 Effective Performance
3 Proficient Performance
2 Developing Performance
1 Introducing Performance

Components/Criteria:

Skill Execution—Student passes the ball accurately, reaching the intended receiver.

Decision Making—Student makes appropriate choices when passing (i.e., passing to an unguarded player so he or she can score).

Support—Student attempts to move into positions to receive a pass from a teammate.

Effort—Student shows good effort by maintaining an average heart rate in his or her aerobic heart rate zone.

Name	Skill Execution	Decision Making	Support	Effort
Matt	a) 4	a) 5 b) 4	a) 5 b) 5	a) 5-Avg. HR 182 b) 5-Avg. HR 185
Mary	a) 5	a) 3 b) 3	a) 4 b) 3	a) 5-Avg. HR 178 b) 3-Avg. HR 130

Mauch, L., personal communication with author, 2000.

Second, heart rate monitors may be used to provide some information about how well goals have been met. Each student could, with teacher assistance, establish a goal for decreasing resting heart rate, or for increasing the length of time a target heart rate can be maintained. If realistic goals are set, then grades can indicate how well the student met a goal.

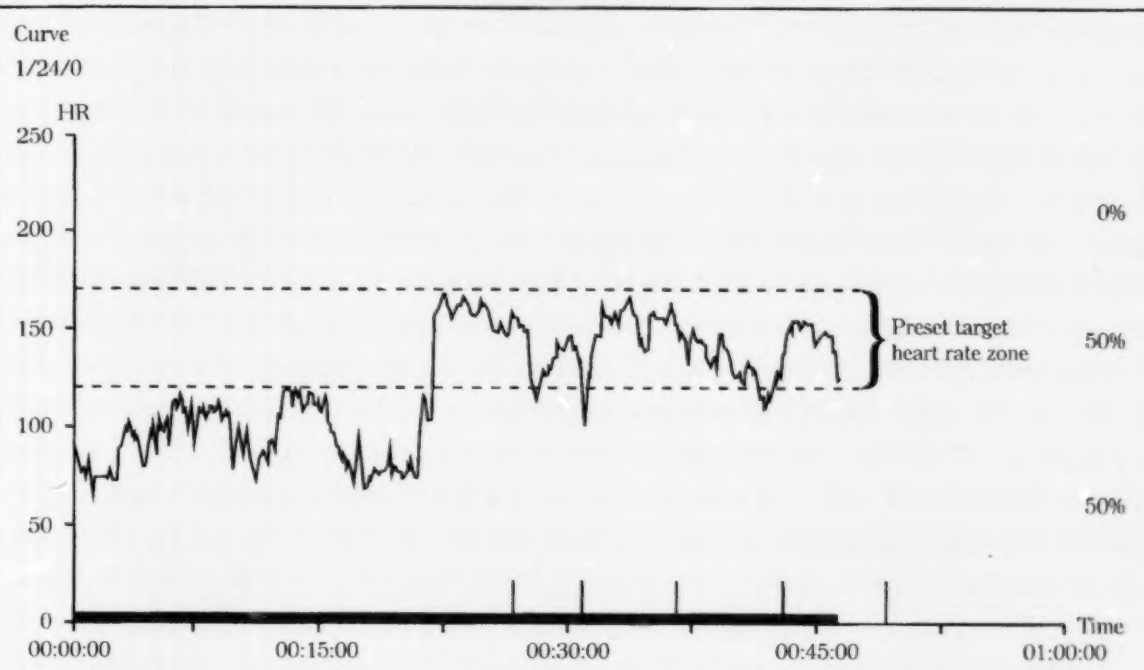
Third, if changes in cardiovascular fitness are a part of the grading, then sufficient time must be provided to expect changes in these measures. That means some class time or outside assignment that prescribes 20-30 minutes of exercise per day will need to be planned over an adequate period of time for changes to occur. Performance on fitness test results should not be the primary means for assigning grades. Correctly performing the tests, interpreting the results, and reflecting on findings, as well as setting and achieving goals, could be used for class assessments. Students may be graded on the degree to which they demonstrate understanding of information from heart rate monitoring and how it can be used to evaluate and set goals.

Assessing effectiveness of instruction. Heart rate monitors can be one indicator of the effectiveness of instruction. Reviewing the curves from heart rate monitor data that has been downloaded to a computer allows a teacher to evaluate some aspects of that lesson. First, in a very visual format, the time spent talking when the students are not active is obvious. Goals can be developed and progress checked in subsequent lessons to limit the length of each segment of talking and to increase activity time. Second, if one of the goals of the lesson is to improve cardiovascular fitness, then heart rate monitors can be used to determine if the students are active for adequate time and intensity (note considerations in setting target zones) to expect improvements in cardiovascular fitness to occur. Third, the teacher can determine if individual drills or activities are aerobic or if modifications need to be made to the activity to

increase and reduce physical activity intensity for specific students or the class overall.

Figure 5 is an example of a curve that can be analyzed in this manner. The average heart rate was 119 bpm. The percent of time in the target zone was 50%, the time spent above the zone was 0%, and the time spent below the zone was 50%. In this class there was very little activity for the first 22 minutes. It appears there was a warm-up period and then a segment of talking and/or waiting for 5 minutes and 30 seconds (5:30). Figure 6 is a graphical representation of the percent of time in, above, and below the target heart rate zone. Note: Non-active time may be important to physical education instruction, but it is critical that physical education classes provide a substantial amount of physical activity most of the time.

Figure 5. Heart rate curve created from a heart rate monitor–45 minute session.



Time: 00:00:00
Heart Rate: 90 bpm
High: 170
Low: 120

Recovery: 00:00:00 – 00:46:05 Value: -35
Average: 119 Maximum: 168 Heart Beat Sum: 5483

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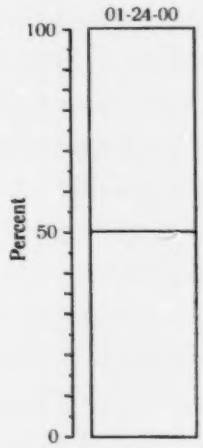
Figure 6. Graph of time in target heart rate zone.



File Summery

Total Time:	00:46:05	
Above Target Zone:	00:00:00	0%
In Target Zone:	00:23:00	50%
Below Target Zone:	00:23:05	50%
Target Zone Limits	Low: 120 High: 170	

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Figure 7. Point Systems for Heart Rate Monitors

Heart Rate Monitor on Stress	Heart Rate Monitor on Fitness
Stress (10 Points) ■ Stress inventory sheet ■ Results from biofeedback lab ■ List of stressors in life before starting your action plan ■ Use of the heart rate monitor to evaluate stressors in your life ■ Action plan ■ Stress inventory (post intervention) ■ Analysis (Did you improve/reduce stress as shown by the printouts of the heart rate monitor?)	Fitness (15 Points) ■ Fitness assessment (cardiovascular) ■ Fitness education pyramid study sheet ■ Results from the HRM printout ■ Journal on the applications of the F.I.T.T. principles ■ Use of the HRM to evaluate your fitness level ■ Action plan and goals ■ Re-evaluation (post fitness assessment) ■ Analysis (Did you improve as shown by the printouts of the HRM?)
You could also include point(s) for each of the subcategories. Stress inventory sheet (1 point), results from biofeedback lab (2 points), use of the heart rate monitor to evaluate stressors in your life (3 points), etc.	You could also include point(s) for each of the subcategories. Fitness assessment (2 points), study sheet (1 point), HRM printout (1 point), journal (4 points), etc.

Mauch, L., personal communication with author, 2000.

Figure 8. Quantitative Analytic Rating Scale

The Student:	Never 0	Sometimes 1	Usually 2	Always 3
Understands how to use the heart rate monitor				
Maintains a minimum of 10 minutes in the target heart rate zone				

Mauch, L., personal communication with author, 2000.

Figure 9. Qualitative Analytic Rating Scale	
Using the Heart Rate Monitor	**Execution**
4 Student understands and uses the heart rate monitor correctly with no problems.	4 Student executes a minimum of 10 minutes in his/her aerobic target heart rate zone.
3 Student understands and uses the heart rate monitor correctly most of the time with no problems.	3 Student executes a minimum of 7-9 minutes in his/her aerobic target heart rate zone.
2 Student understands the use of the heart rate monitor but does not use it correctly.	2 Student executes a minimum of 4-6 minutes in his/her aerobic target heart rate zone
1 Student has little or no understanding of the heart rate monitor or its use.	1 Student executes less than 4 minutes in his/her aerobic target heart rate zone.
Mauch, L., personal communication with author, 2000.	

Figure 10. Holistic Rubric	
Level Four Student understands and uses the heart rate monitor correctly with no problems. Student executes a minimum of 10 minutes in his/her aerobic target heart rate zone.	**Level Two** Student understands the use of the heart rate monitor but does not use it correctly. Student executes a minimum of 4-6 minutes in his/her aerobic target heart rate zone.
Level Three Student understands and uses the heart rate monitor correctly most of the time with no problems. Student executes a minimum of 7-9 minutes in his/her aerobic target heart rate zone.	**Level One** Student has little or no understanding of the heart rate monitor or its use. Student executes less than 4 minutes in his/her aerobic target heart rate zone.
Mauch, L., personal communication with author, 2000.	

Rubrics. Lois Mauch, a middle school NASPE Teacher of the Year from Fargo, North Dakota (Mauch, L., 2000) has created several rubrics that can be used with information obtained from heart rate monitors. Figures 7-10 are examples of rubrics to be used with heart rate monitors or to assess knowledge of heart rate monitor use.

Summary

Research supports the use of heart rate as a means of measuring physical exertion and that heart rate monitors are a valid and reliable instrument for measuring heart rate. Uses of heart rate monitors for general purposes as well as educational uses were presented. Suggestions about interdisciplinary themes, motivation in classes, fitness and effort, and grades were provided. Physical activity levels and fitness of youth is a major health concern at this time. The improvement of fitness, as well as increasing the understanding students have of the importance of fitness and how to become fit and maintain appropriate levels of physical activity, must be priorities.

Technology is important, but knowing the fundamentals of heart rate monitoring is equally important. It is like learning to use a calculator in math class – students also need to learn the times tables and how to do long hand division. Heart rate monitors can be an important tool to enhance student learning in the areas of physical activity and fitness as well as to help develop understanding about how the body responds to exercise. It is necessary for physical education to take advantage of technological advancements that are available to improve teaching and learning. Technology such as heart rate monitors helps to reinforce the importance of including physical education as a required subject in the curriculum. This is an exciting time to begin to use heart rate monitors and other technologies to enhance the attainment of all physical education objectives.

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